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A Story About Critters that Dine On New Hampshire Oysters

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—Sarah Mikulak

"…the world's mine oyster"
William Shakespeare, *The Merry Wives of Windsor*

Today, when we say "the world's [my] oyster," we think of reaping the benefits and riches of life. Oysters, themselves, however, offer benefits and riches for us and their natural habitat. Besides providing enjoyment for recreational harvesters and tasting scrumptious with cocktail sauce, oysters and their reefs play important roles in their watery world.

About Oysters

A group of live oysters and the substrate, or *cultch*, on which they live, together form an oyster reef. Natural reefs are created when oyster larva, attracted to the reef by chemical cues emitted by adult oysters, permanently attach themselves to nearby cultch, either rock or shells of dead or living oysters (1). The structure of an oyster reef allows other organisms to live in and around the reef. Spaces between the oysters and the cultch provide protection and habitat for many animals, including snails, fish, worms, and crabs (2). The hard substrate of the reef is also suitable attachment for seaweeds, food for many marine animals.

Typically, oysters do not live in the open ocean. In New Hampshire they are found in the Great Bay Estuary and associated rivers (1). Water in estuaries and rivers contains greater amounts of sediment and nutrients than open ocean waters because of higher amounts of soil run off from the surrounding land. Sediment may bury plants and animals living on the bottom of the bay, and a greater amount of nutrients can increase the chance of an algal bloom. Oysters act as natural filters by removing some of these sediments and nutrients during their feeding process. One adult oyster can filter up to 200 liters (52.8 gallons) of water per day (1).

During the last decade, populations of oysters along the East coast have declined in large measure due to disease that caused a major die-off in Great Bay in 1995 (1). This setback, along with over-harvesting, increased sediment accumulation, habitat loss due to decreased oyster abundance, and predation by crabs and some snails, caused oyster population declines on some New Hampshire reefs (3).

In 2000, a group called the New Hampshire Estuaries Project (NHEP) determined that the oyster is an important recreational fishery, and therefore restoration of New Hampshire oyster reefs was necessary (3,4,5,6). The NHEP set four specific goals for researchers to address during the restoration process: provide enough suitable cultch, address the problems associated with disease, overcome sediment accumulation, and investigate the role of predation on oysters (7). Research on oyster reefs in New Hampshire have addressed and are addressing the first three goals; however, missing in the oyster research program is the fourth goal: the study of predation on constructed reefs (8). Predation on oysters in natural reefs has been extensively researched in New Hampshire and along the East coast, whereas research of predation on constructed reefs has been conducted only in Virginia.

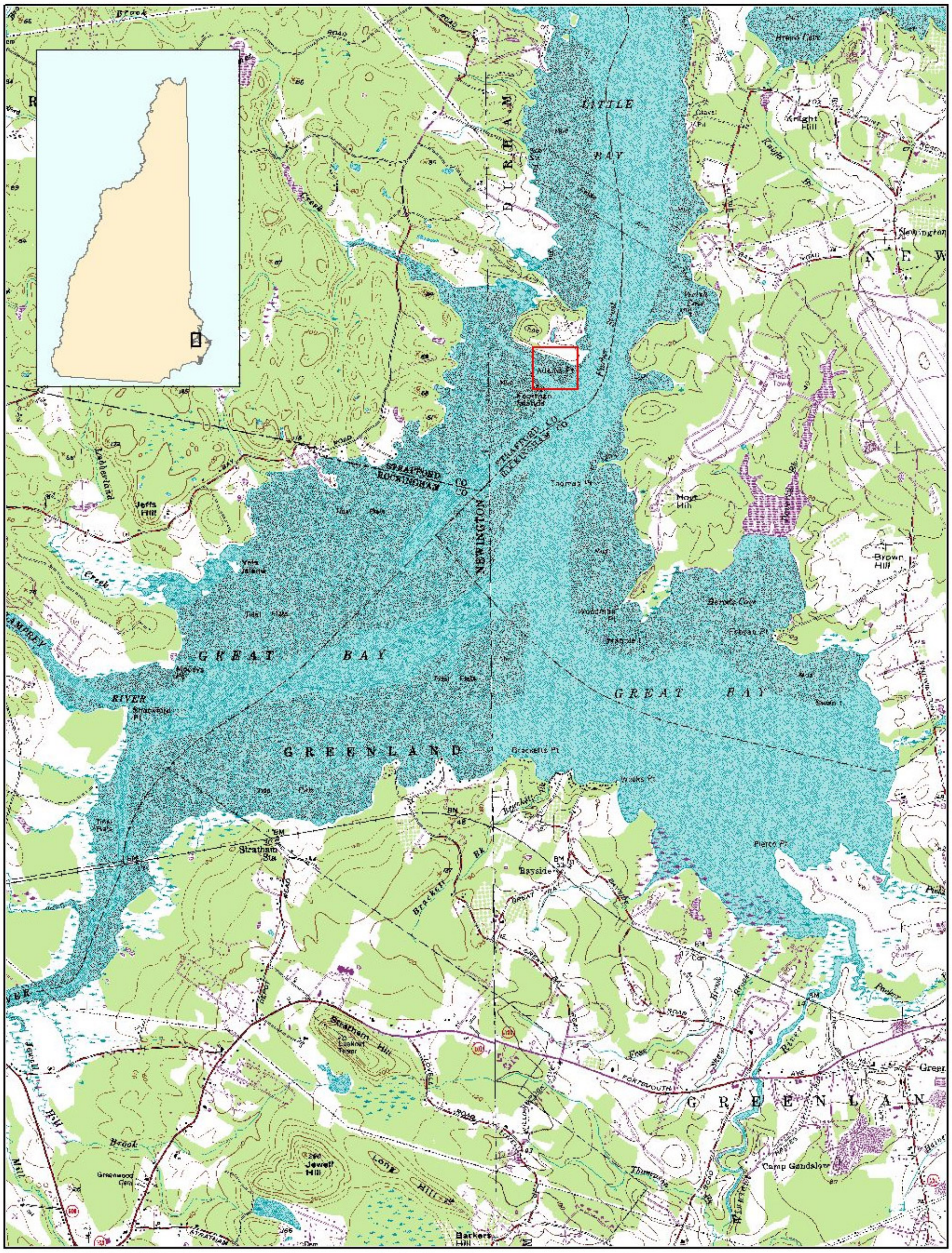

Figure 1. USGS topographic map of study site and surrounding area.

I designed a project in New Hampshire to research predation on constructed oyster reefs in hopes of answering several questions: What kinds of animals are predators on the reefs? How could I determine the impact of predation on the oyster population? Do the characteristics of the reef, such as live oyster density and cultch type, influence the predator population? The answers to these could lead to recommendations for future reef restoration projects.

Study Site

I ran my experiment during the summer of 2004 on an experimental oyster reef constructed the previous summer near UNH's Jackson Estuarine Laboratory at Adams Point in Great Bay.

To restore oyster reefs, researchers use large tanks to settle larva onto suitable cultch, and then place the cultch and juvenile oysters in a prepared area in the bay. The idea is that enough of these oysters will survive the three years needed for maturity, and then spawn themselves, adding to the small reef created by the researchers.

The reef I used was initially built to determine if the type of cultch and the population density of live oysters influenced oyster growth on a constructed reef. The two cultch materials used in this project were crushed concrete (referred to as rock) and dead, empty oyster shells. The two live oyster densities tested were a high density and a low density. The layout of the reef consisted of twelve mini-reefs, each 2 meters by 3 meters, with four combinations of cultch and oyster density: Rock/High, Rock/Low, Shell/High, and Shell/Low. Three mini-reefs of each combination were randomly distributed within the experiment area (Fig. 2).

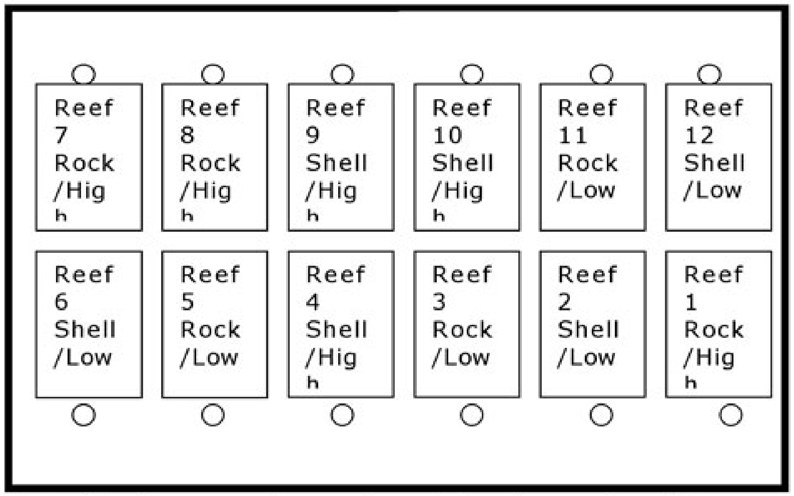

Figure 2. Diagram of experimental oyster reef on Adams Point. The substrate for each reef is either Rock or Shell, and the oyster density is either High or Low. The circles

Collection of Predators

The design of the collection buckets was based on a similar experiment conducted in Virginia. I made my buckets by cutting two-gallon buckets in half and attaching a rope handle with an identifying buoy to the bottom half. One bucket was made for each mini-reef. To simulate the reef, each bucket was filled with the same cultch material as the mini-reef it was placed next to, either rock or empty oyster shell (Fig. 3).

Figure 3. Pictures of the observation buckets containing the reef substrate. Oyster shell is on the left and crushed concrete (rock) is on the right.

The top of the bucket was at the surface of the sediment, thus allowing organisms to freely move in and out of the bucket. At low tide, waist to chest high water covered the reef.

To collect and deploy the buckets, I waded in the water, pulled up the buckets and handed them to assistants on a boat. Each collection bucket was placed in its own five-gallon bucket to keep the organisms in water. I then immediately reset a second set of identical collection buckets next to their mini-reefs. This procedure was carried out weekly for eight weeks, during which the organisms were identified, counted, and measured. After processing, the organisms were then released into Great Bay from the Jackson Laboratory dock.

Results and Conclusions

During my study, crabs were the only oyster predator collected. Both species of crab, the Say mud crab (*Dyspanopeus sayi*) and the rock crab (*Cancer irroratus*), collected at the reef are oyster predators (Fig. 5) (9). The two measurements used to estimate the potential effect of these crab predators living on the reef were carapace width (size) and population density.

A previous study had found that adult mud crabs, average size 15.12 mm, and adult rock crabs, average size 37.88 mm, were able to break into oyster shells (9). All the rock crabs I collected were large enough to kill oysters. Of the mud crabs collected, only those whose size was greater than 10 mm were counted because smaller ones could not open an oyster.

Figure 5. Pictures of the two species of predatory crab collected during the study. The mud crab (left), the smaller of the two species, had a greater population density than the rock crab (right).

Where humans have knives to pry at the joint of an oyster shell, crabs have to fight with the actual oyster shell, which thickens as the oyster grows. To open an oyster, a crab either crushes the middle of the shell at a thin area or chips the edge of the shell. An oyster shell may be too thick for a certain-sized crab to open, though a larger crab may be able to open that same oyster (9). Generally, as the crab size increases, the size-range of oysters that the crab is able to eat also increases. The larger crab species, the rock crab, has more potential to open and eat larger oysters than the mud crab. The mud crab, however, is able to eat smaller, younger oysters and could adversely affect a juvenile oyster population (Fig. 6).

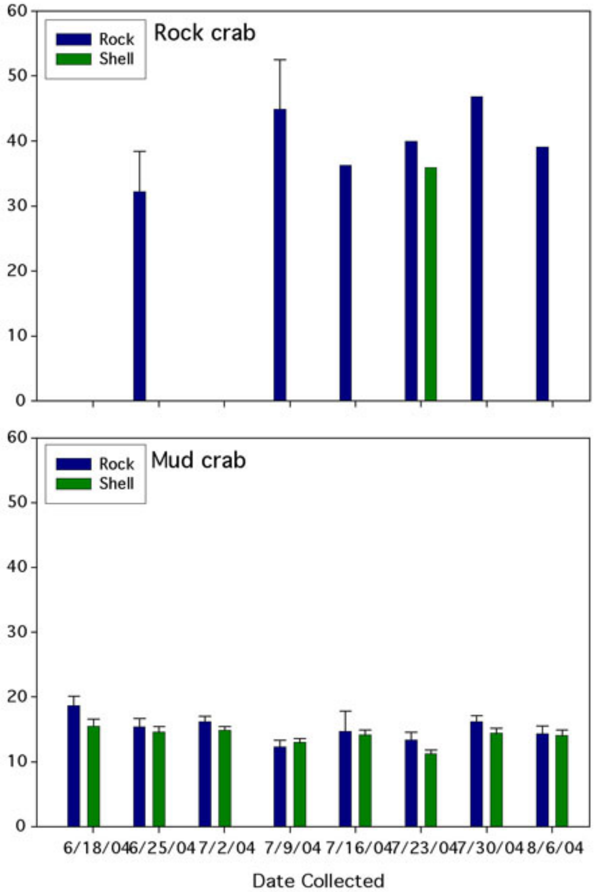

Figure 6. Average size of the predatory crabs in each cultch, rock and shell, for

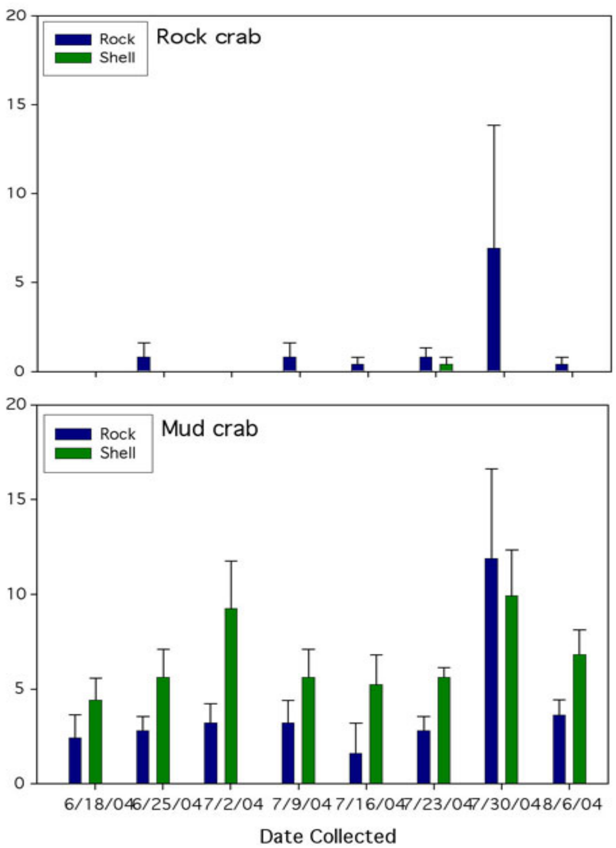

Figure 7. Average population density of the predatory crabs in each cultch, rock and shell, for each week during the

The population density of predators influences the growth of a reef: as the number of predators living on the reef increases, the potential of more oysters being eaten also increases. Statistically, the population of mud crabs at Adams Point is greater than the population of rock crabs ($p = 0.01$) (Fig. 7). The small population of rock crabs is able to eat only a small number of the larger oysters, which does not affect the oyster population as much as does the larger mud crab population, which can eat a greater number of young oysters before they reach reproductive age.

The live oysters on the mini-reefs were what attracted the crabs, while the cultch in the adjacent buckets created ideal living space for them. It would seem that more oysters would attract more crabs; however, there was no statistical difference ($p > 0.05$) between the population densities of mud crabs found in the buckets next to high or low density oyster reefs.

The cultch type did show to influence the population densities of the crabs. The sizes of the spaces between the pieces of cultch, or interstitial spaces, in the buckets were different for rock and shell (Fig 3). The shells used were smaller and fit together better than the rock, thus creating smaller interstitial spaces. The rocks were variable in size and created large pockets of space. Since the buckets were simulating the reef, these conditions would be present on a reef as well.

Observations during this study showed that all 584 different crabs that I handled, regardless of size or species, always tried to hide when placed in open spaces. In plastic bags filled with water, they sought the corners and folds of the bag for hiding places. In a dish they partially enclosed themselves by backing up against the side. Based on these observations, I deduced that the crabs would seek the smallest possible hiding places in the reef as well. Since the cultch types create different sized environments, different sized crabs may prefer one type over the other.

The mud crab, the smaller species, statistically had a greater population density in the shell than the rock buckets ($p = 0.02$). The smaller, snugger interstitial spaces of the shells attracted the mud crab more than the larger spaces of the rock. All but one rock crab was observed in a rock bucket, which may mean that they prefer the larger interstitial spaces—or possibly that they can't fit into the spaces in the shell.

Rock cultch has not only larger interstitial spaces, but fewer of them, and the opposite is true for shell. Crabs are solitary creatures, so the perfect habitat for them is a space just big enough for them and no other occupants. For the mud crab, the small numbers of large spaces in the rock buckets are just not suitable habitats. The shell provides many small spaces, which the more populous mud crabs prefer.

Present and Future Applications

The findings of this study have major implications for the oyster reef restoration effort. I found that crushed concrete (rock) is an effective cultch to use for constructing reefs because it attracted fewer predatory crabs than did oyster shell. I also found that the oyster density did not influence the predatory crab population density. When constructing an oyster reef, the main goal is to maximize oyster growth and survival into adulthood. Since the oyster density may not affect the crab density, researchers constructing oyster reefs could initially stock a reef with a greater density of oysters knowing that the greater number of oysters will not attract a greater number of crabs.

This study, the first of its kind in New Hampshire, was conducted in a small area of Great Bay, an estuary with many variable conditions. During the time of this study, another oyster predator, the Atlantic oyster drill (*Urosalpinx cinerea*), was found living on an oyster reef just across the bay. Since this predator was not seen in this study, the predatory dynamics may be different on that reef. Because of the variability of conditions and the fact this is the first study to explore this question, these findings should be used for future projects as a basis of comparison to determine if they are consistent with reefs in other locations.

I would like to thank Dr. Ray Grizzle and Jennifer Greene for guidance and assistance with the entire research process. Thanks also to Holly Abeels, Michelle Graffam, Ryan McDermott, Mark Capone, Jessica Pearson and Eric Dugre for help with processing. This study was funded by a Summer Undergraduate Research Fellowship awarded by the University of New Hampshire's Undergraduate Research Opportunities Program.

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Author Bio

Sarah Mikulak, a senior from Connecticut, is majoring in marine and freshwater biology. When invited to join an oyster restoration project, she applied for and received a Summer Undergraduate Research Fellowship for 2004. "The best part of the project was that I got to play in the mud," she asserts, although sorting out her subjects and conveying them to the Jackson Estuarine Laboratory was laborious. However, by the end of the summer she knew that she could conduct a research project by herself. In the future, Sarah wants to use her knowledge and experience to conserve and restore marine ecosystems.

Mentor Bios

Sarah was mentored in her project by Professor Raymond Grizzle, research associate professor in Zoology. Grizzle specializes in invertebrate Zoology and works principally in coastal waters. This was the first SURF project he has mentored in his five years at UNH. He helped Sarah get started and was a constant resource for her. "I am really proud of her and the work she has done," he says, and is himself pleased with the new ideas and information about oyster predation that he gained through his mentorship.

Sarah's project was a spin-off of research on oyster reef restoration techniques conducted the previous year by Jennifer Greene, a senior laboratory technician at the Jackson Estuarine Laboratory. Jennifer supported Sarah's work in many ways—from ordering supplies, to driving the boat, to teaching her new skills she will use beyond college. Jennifer felt the most interesting part of the project was retrieving collection buckets and learning more about oyster reef predators in Great Bay.